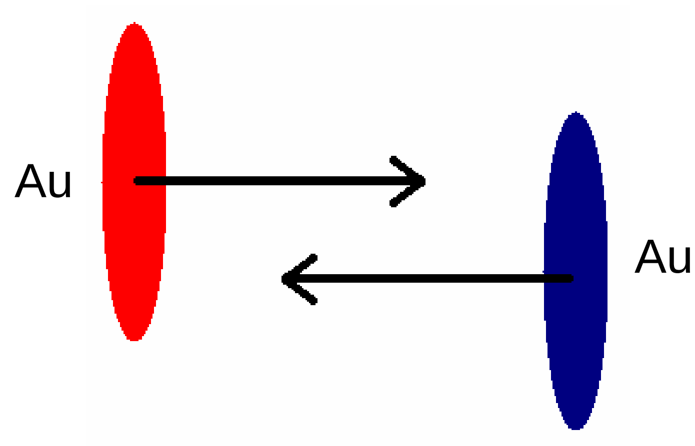
Ultra-Relativistic Heavy-Ion Collisions

PHENIX@RHIC and ALICE@ LHC

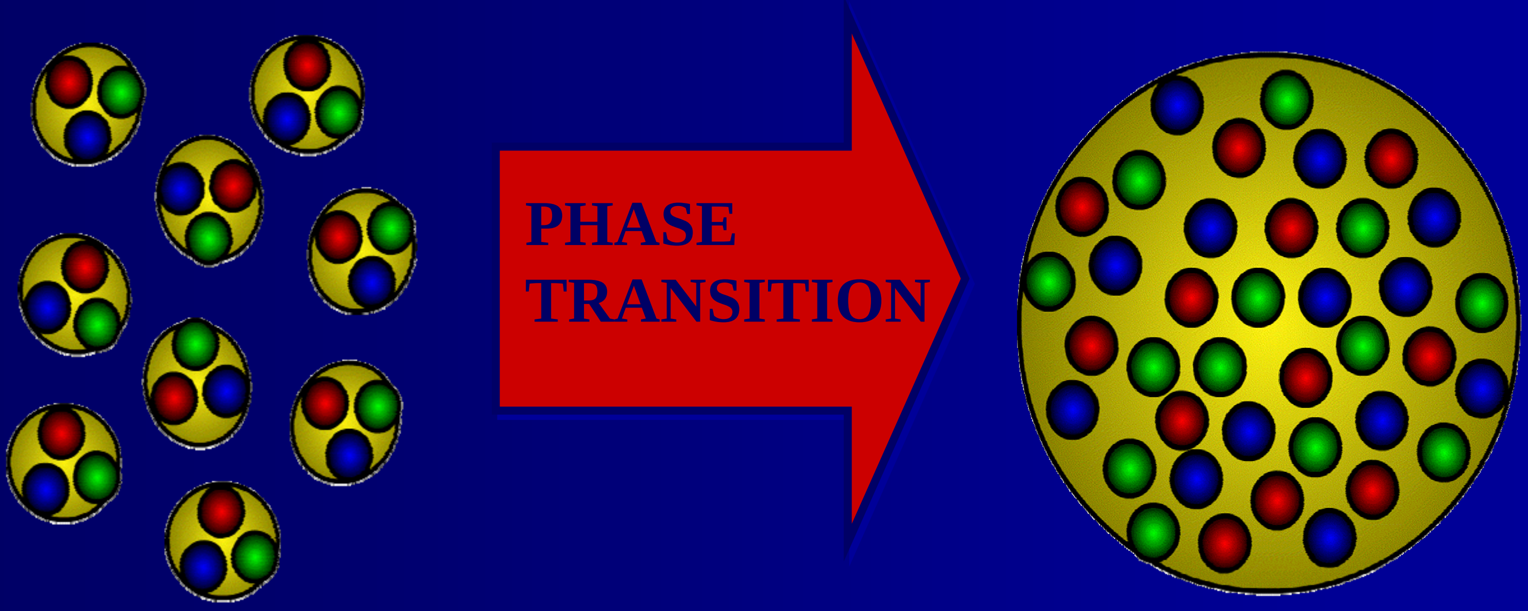


Group: Peter Christiansen, Hans-Åke Gustafsson, Eva Haslum, Anders Oskarsson, Sarah Rosendahl and Evert Stenlund

PhD students

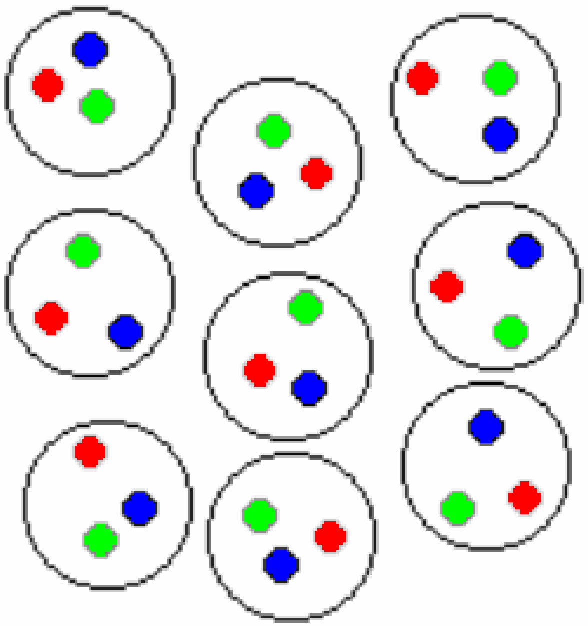
QUARK GLUON PLASMA

DECONFINEMENT

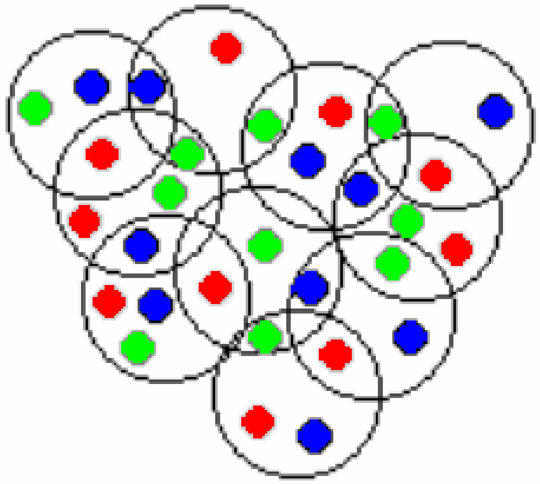


Theoretical calculations (QCD) predicts phase transition at large enough temperatures and/or densities.

$\Rightarrow$ *deconfinement* of quarks

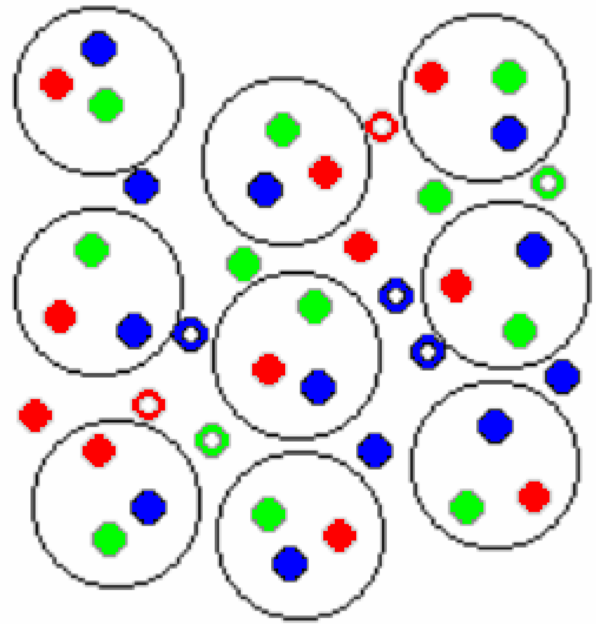


In nuclear matter at normal temperatures and densities, quarks are confined into the nucleon bubbles.



When the pressure increases quarks are getting closer and no longer belong to a unique bubble.

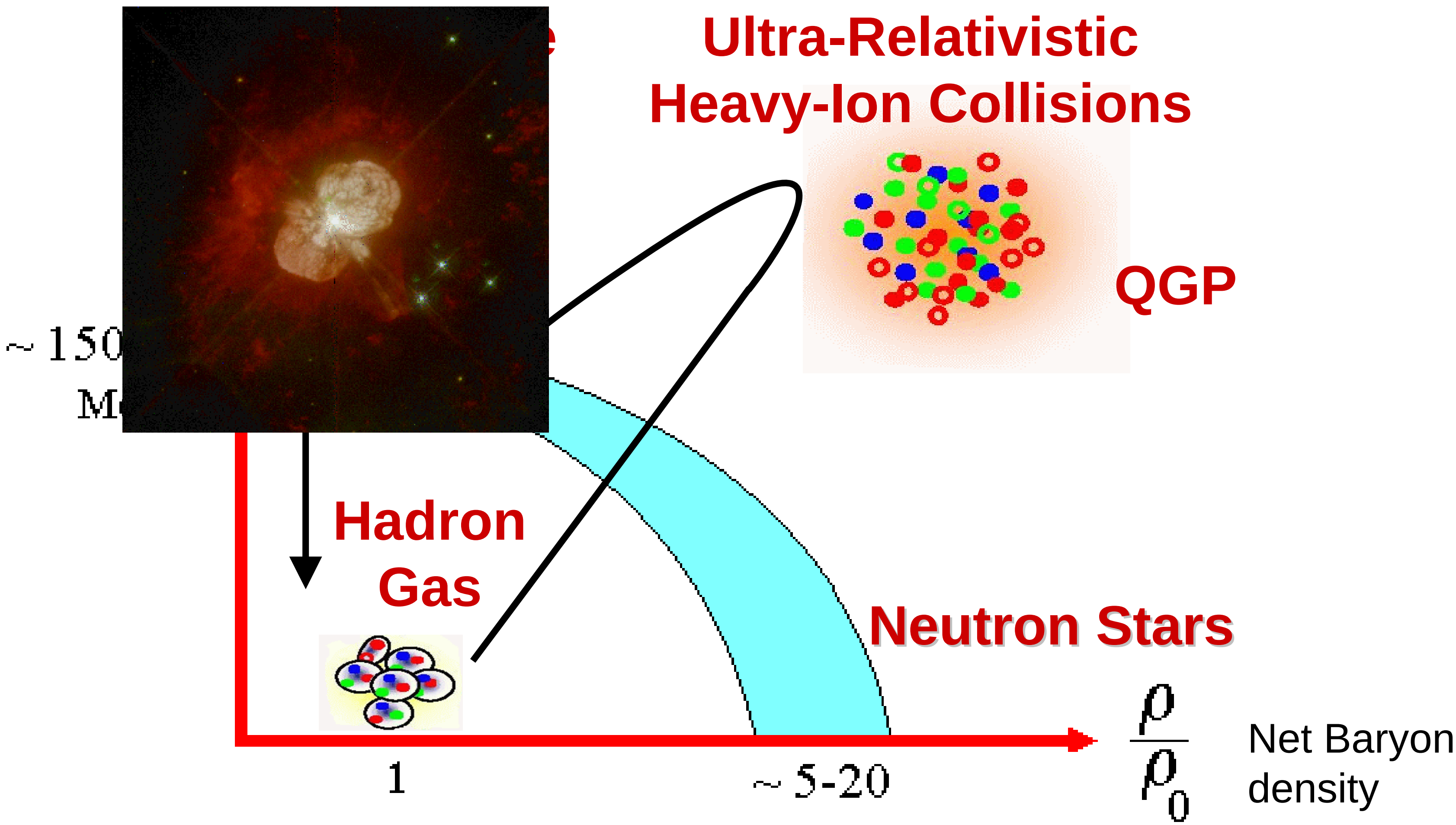
High Net Baryon density



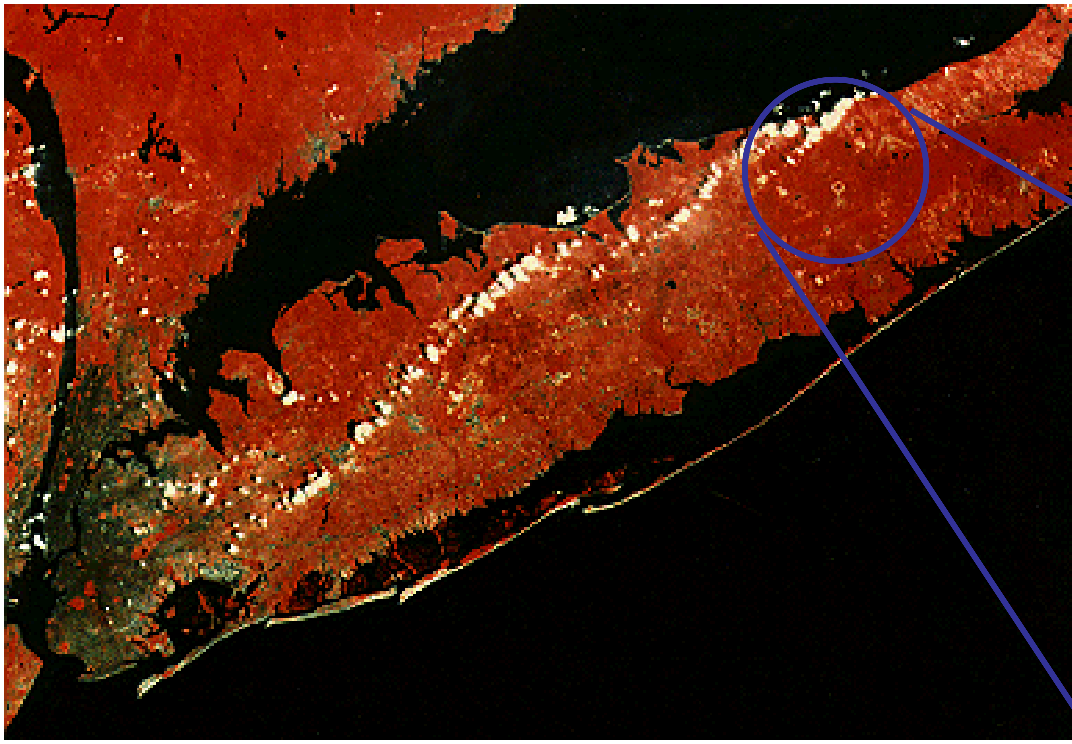
When the temperature increases $q\bar{q}$-pairs will appear in the field, and again the quarks will come closer to each other.

Low net baryon density

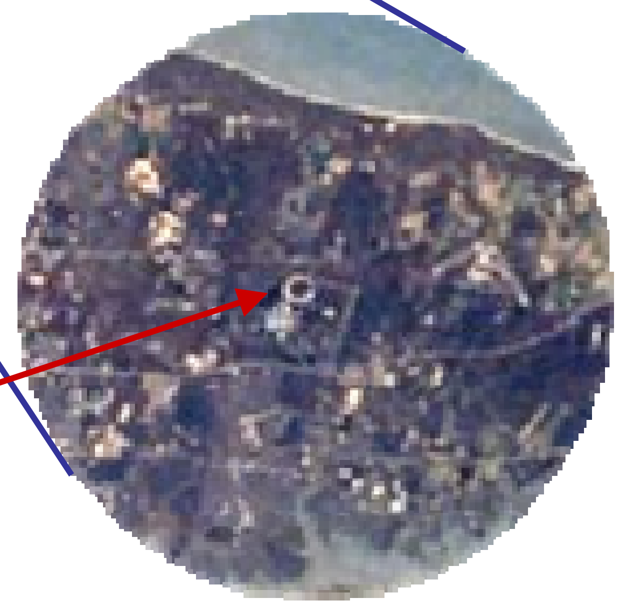
The Quark-Gluon Plasma



Brookhaven National Laboratory and RHIC can be seen from space ...

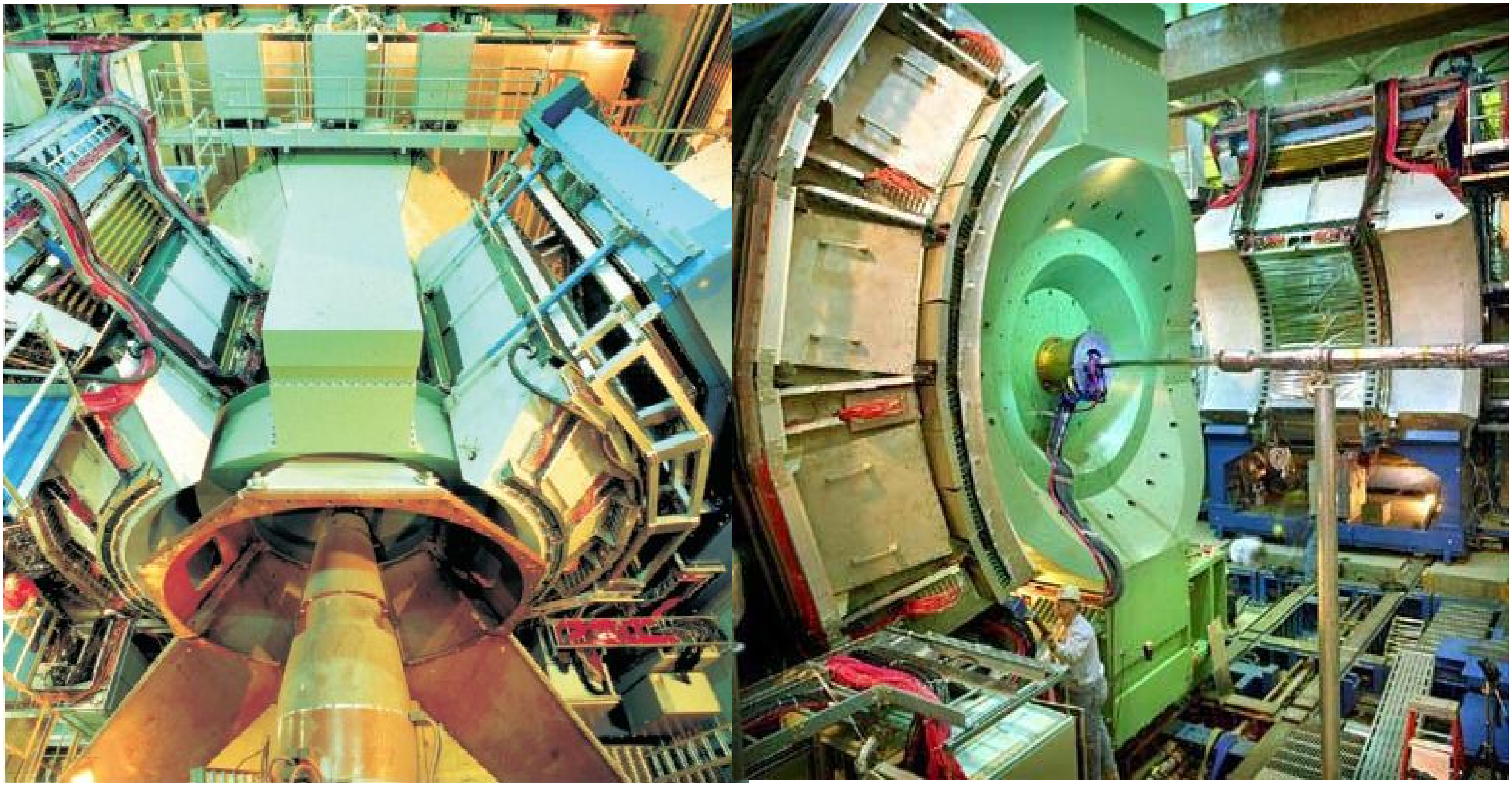


...here on a satellite picture over Long Island



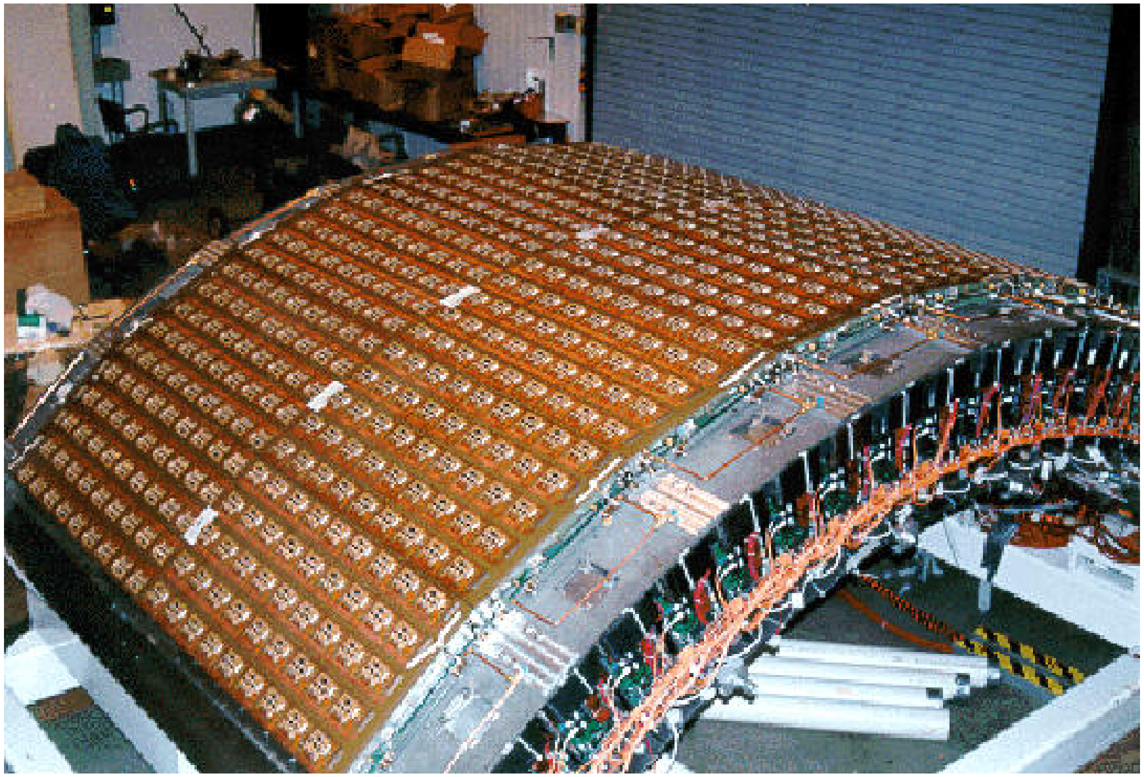
Relativistic Heavy-Ion Collider RHIC


PHOBOS
RHIC
STAR
BRAHMS
PHENIX
ATR
Circumference ~ 3.8 km
Maximum energy per beam
(Au) 100 AGeV
Injection energy 9 AGeV
6 intersections (4 for exp.)
lisions June 2000
STAR
Tandem



PHENIX, Taking
data since 2001

The Pad chambers in PHENIX
Lund Hardware contribution



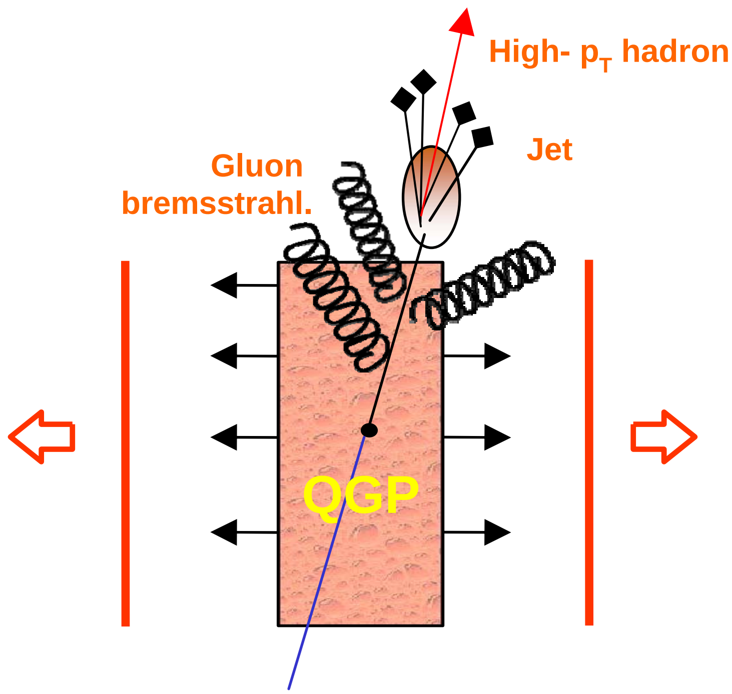
- Five planes: East PC1,3 & WEST PC1,2,3
- $\Delta\varphi$=90°, $|\eta|$=0.35
- 80m^2 MWPC, pixel cathode readout,
- 172800k readout channels,
- 1.2% χ_0 (PC1) with electronics on back

Jet quenching

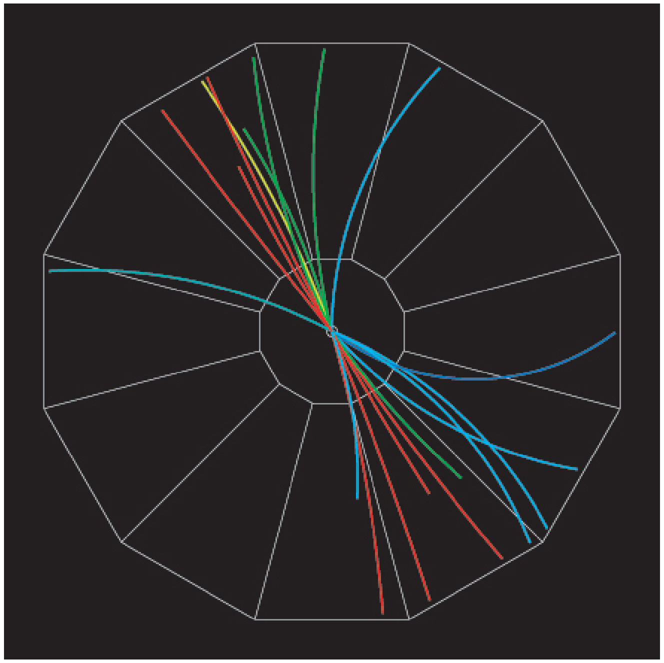
A signal of QGP

When a coloured object moves through a coloured plasma it loses energy.

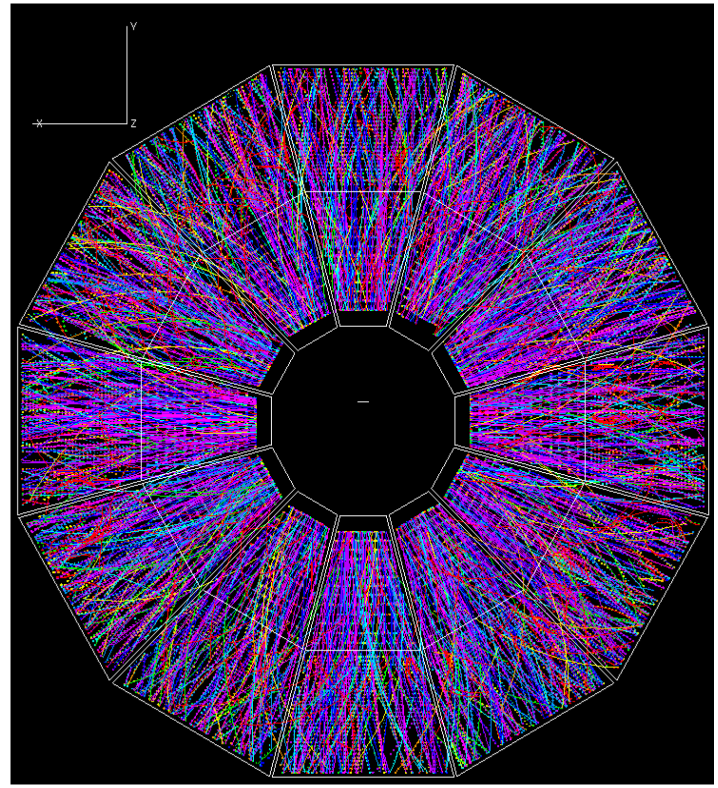
High-p_T production is expected to be suppressed as compared to the case in p-p collisions, if a QGP is present.



Experimental observation:
Less high-pT hadrons in central collisions than in peripheral.



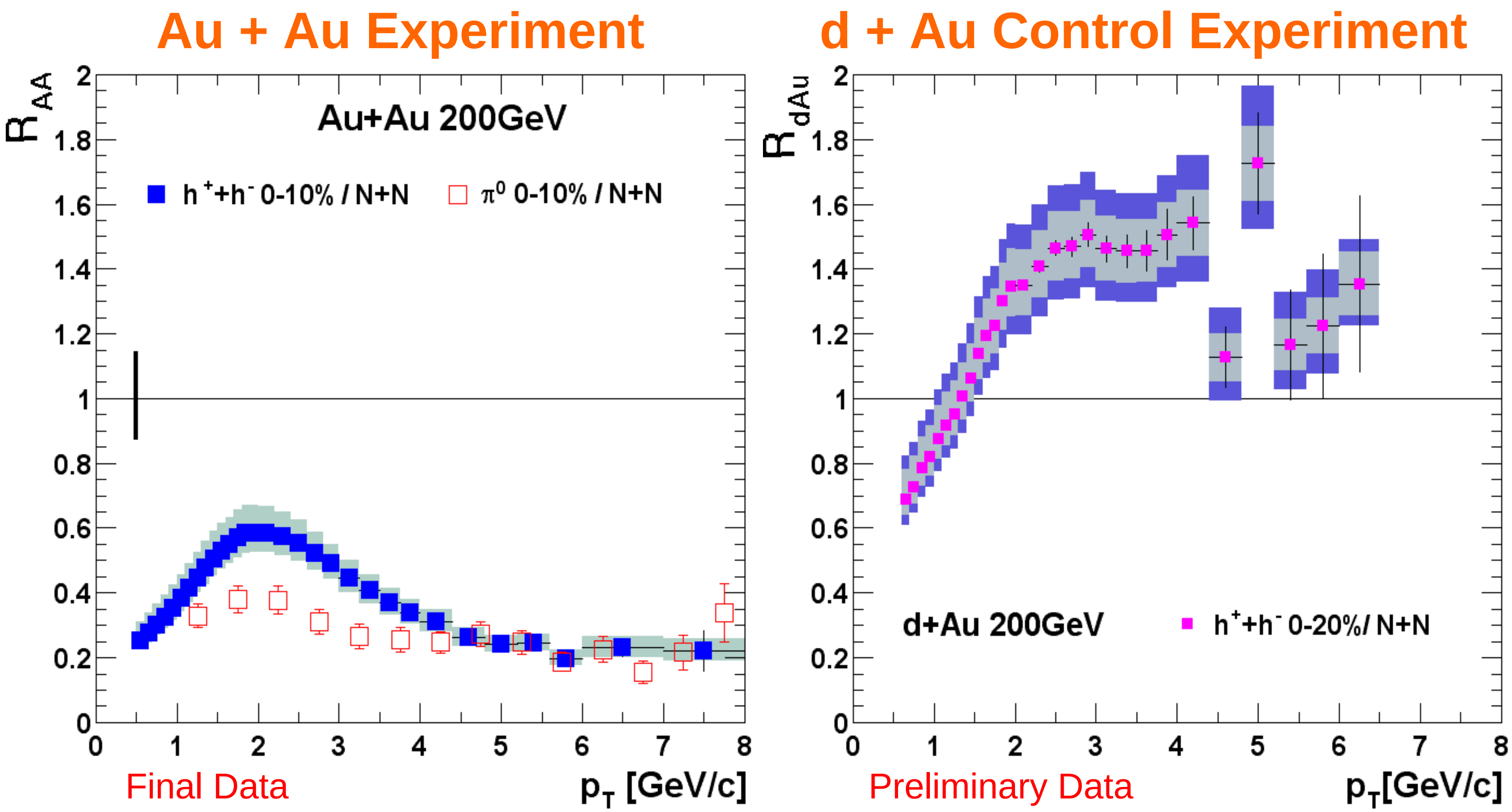
p+p →jet+jet
(STAR@RHIC)



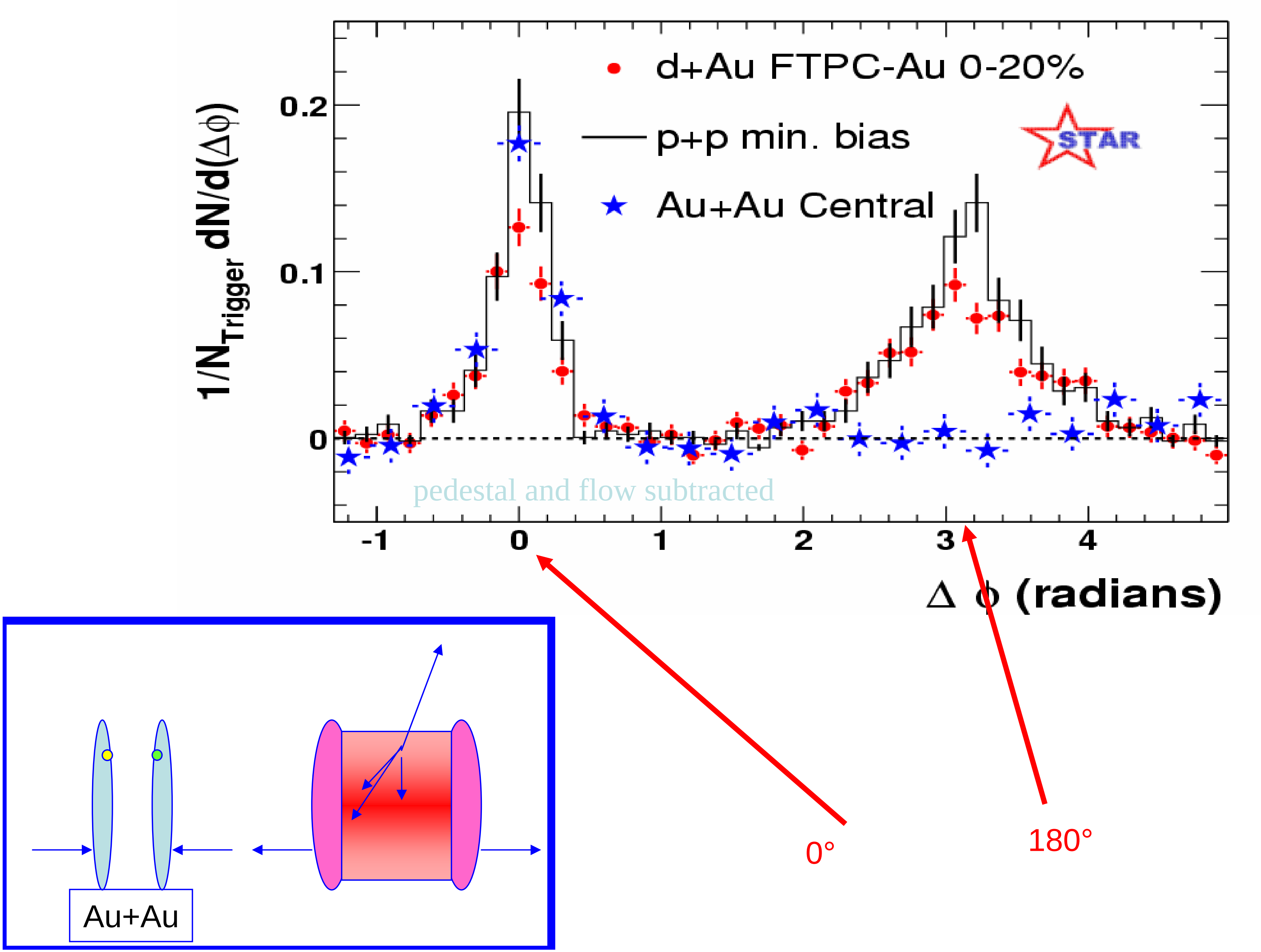
Au+Au →???
(STAR@RHIC)

Find this in this

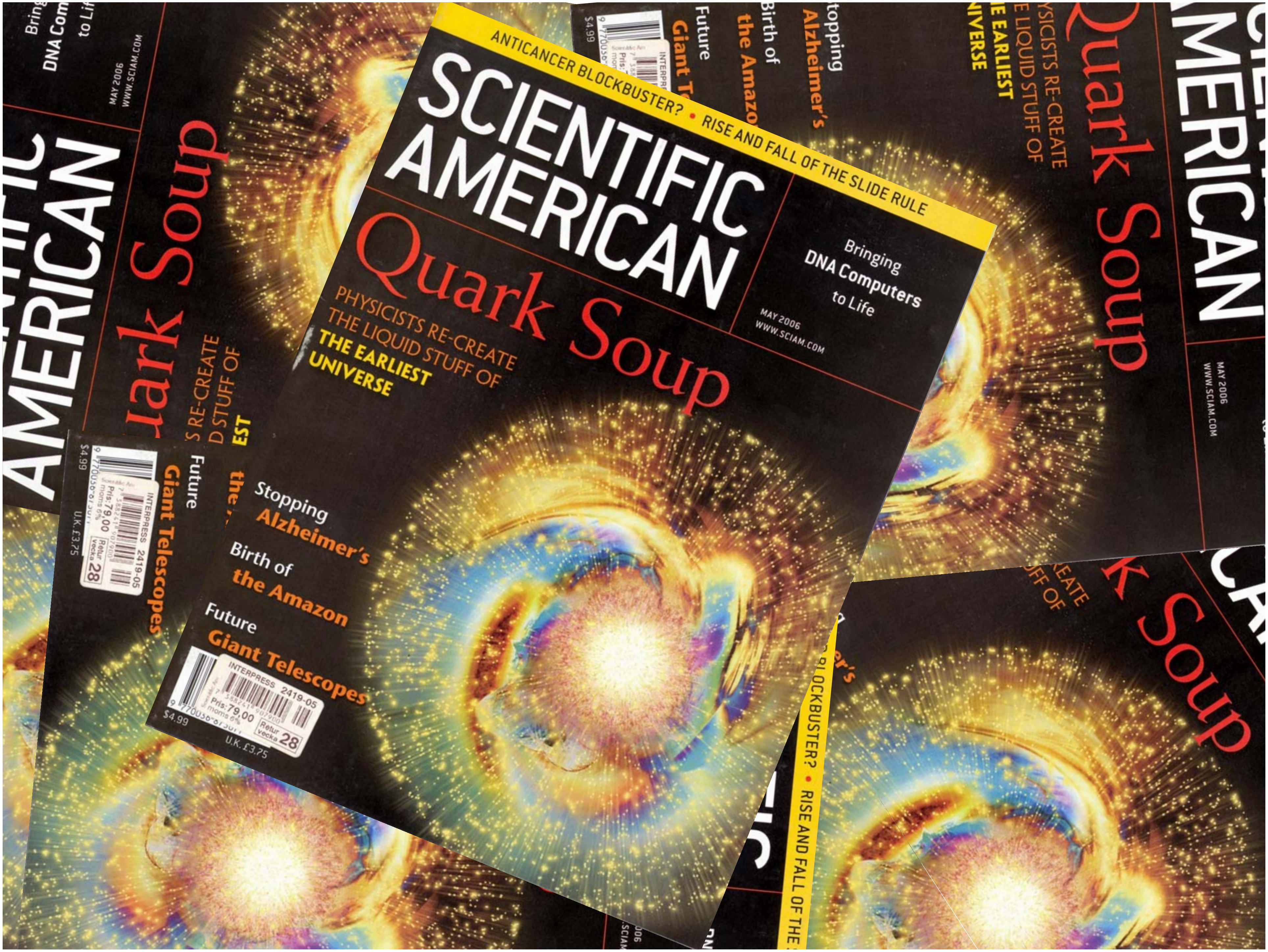
Centrality Dependence



- Dramatically different and opposite centrality evolution of Au+Au experiment from d+Au control.
- Jet Quenching, Suppression of high PT particles.



d+Au FTPC-Au 0-20%
p+p min. bias
Au+Au Central
STAR
$1/N_{Trigger}\, dN/d(\Delta\phi)$
0.2
0.1
0
pedestal and flow subtracted
-1
0
1
2
3
4
$\Delta\ \phi$ (radians)
0°
180°
Au+Au


ANTICANCER BLOCKBUSTER? • RISE AND FALL OF THE SLIDE RULE
SCIENTIFIC AMERICAN
Quark Soup
PHYSICISTS RE-CREATE THE LIQUID STUFF OF THE EARLIEST UNIVERSE
Bringing DNA Computers to Life
MAY 2006
WWW.SCIAM.COM
Stopping Alzheimer's
Birth of the Amazon
Future Giant Telescopes
INTERPRESS 2419-05
Pris: 79,00
Retur vecka 28
$4.99
U.K. £3.75

The state formed at RHIC

- **has a high energy density**
- **has a high temperature**
- **is rapidly thermalized**
- **resembles a liquid with small viscosity**

The flow behaves like a school of fish with a high degree of collectivity with strong interactions between the constituents (quarks and gluons)

An almost perfect liquid

QCD explains pp collisions down to ppm level

BUT

Every nuclear collision gives unexpected result

PhD's in our group since 1997

1997- Joakim Nystrand, post doc Berkeley, Fo.ass Lund, now professor in Bergen

1999- Karim El Chenawi, postdoc Vanderbilt, now OMX

1999- Tom Svensson directly to industry, Kockum submarines computing

2001- Pål Nilsson, Cern fellow, now staff scient at U of Texas

2001- David Silvermyr. Postdoc Los Alamos,Wigner fellow ORNL, now staff scient at ORNL

2004- Henrik Tydesjö, now CERN fellow

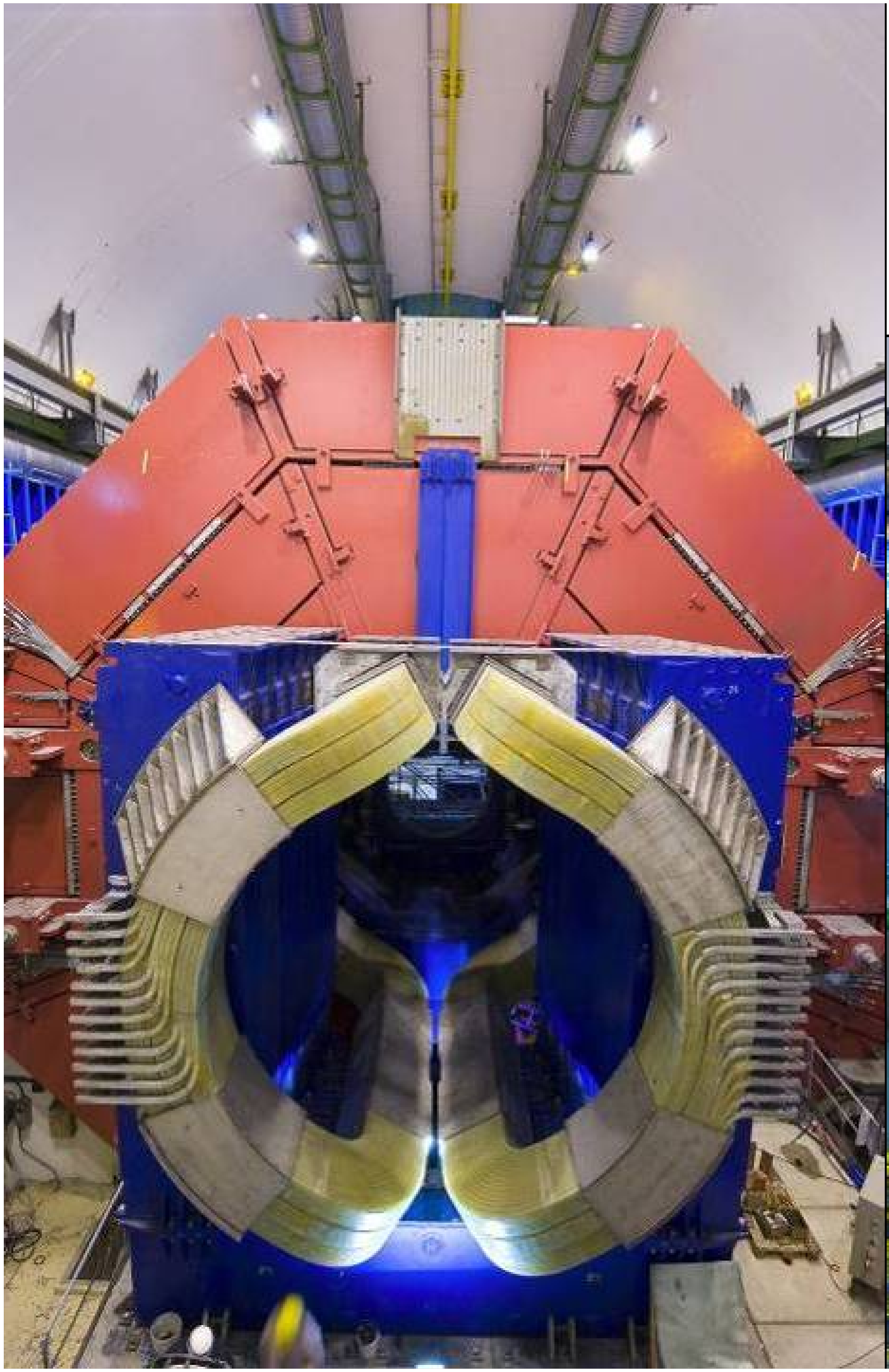
ALICE at LHC from 2007/2008   3.5 + 3.5 TeV   Pb nucl

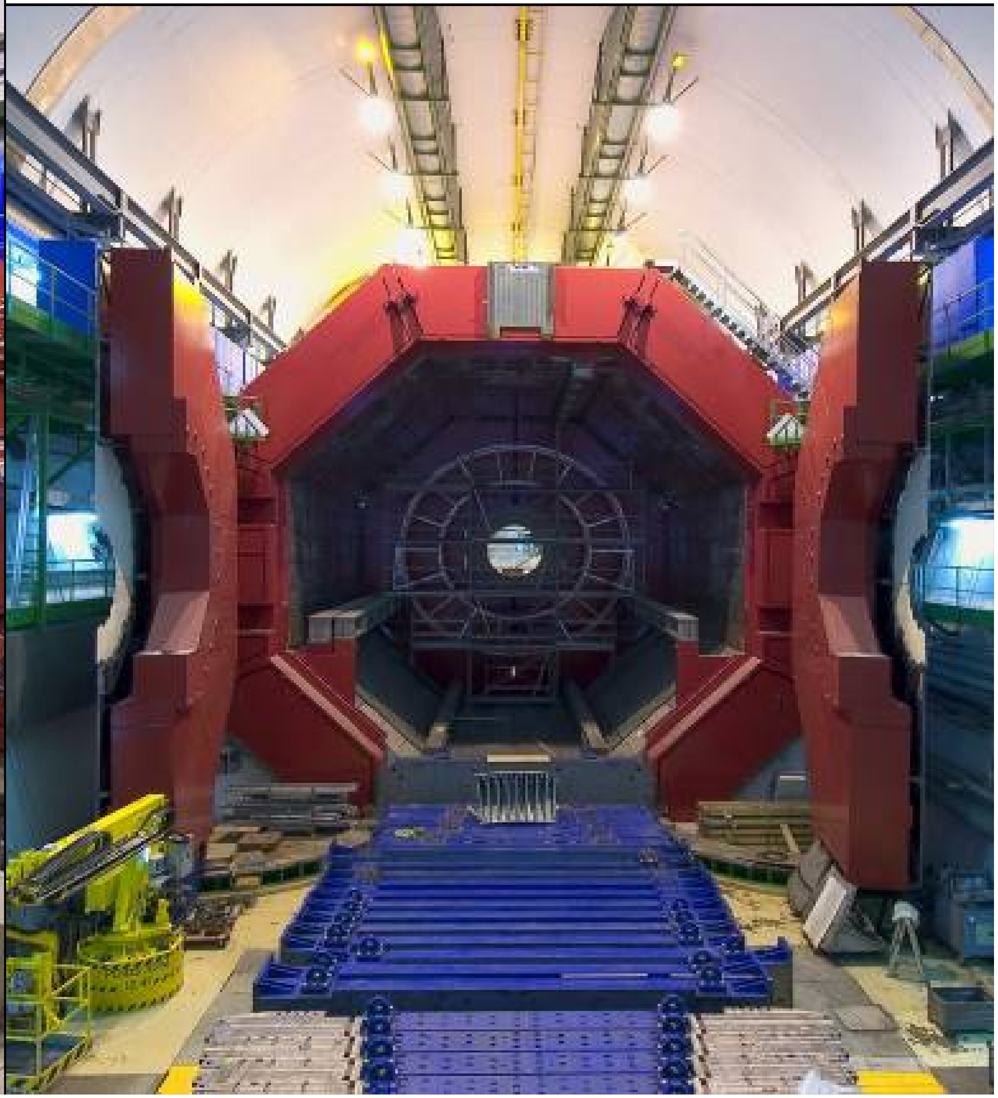
ALICE Pb+Pb collisions 3.5TeV + 3.5TeV per nucleon

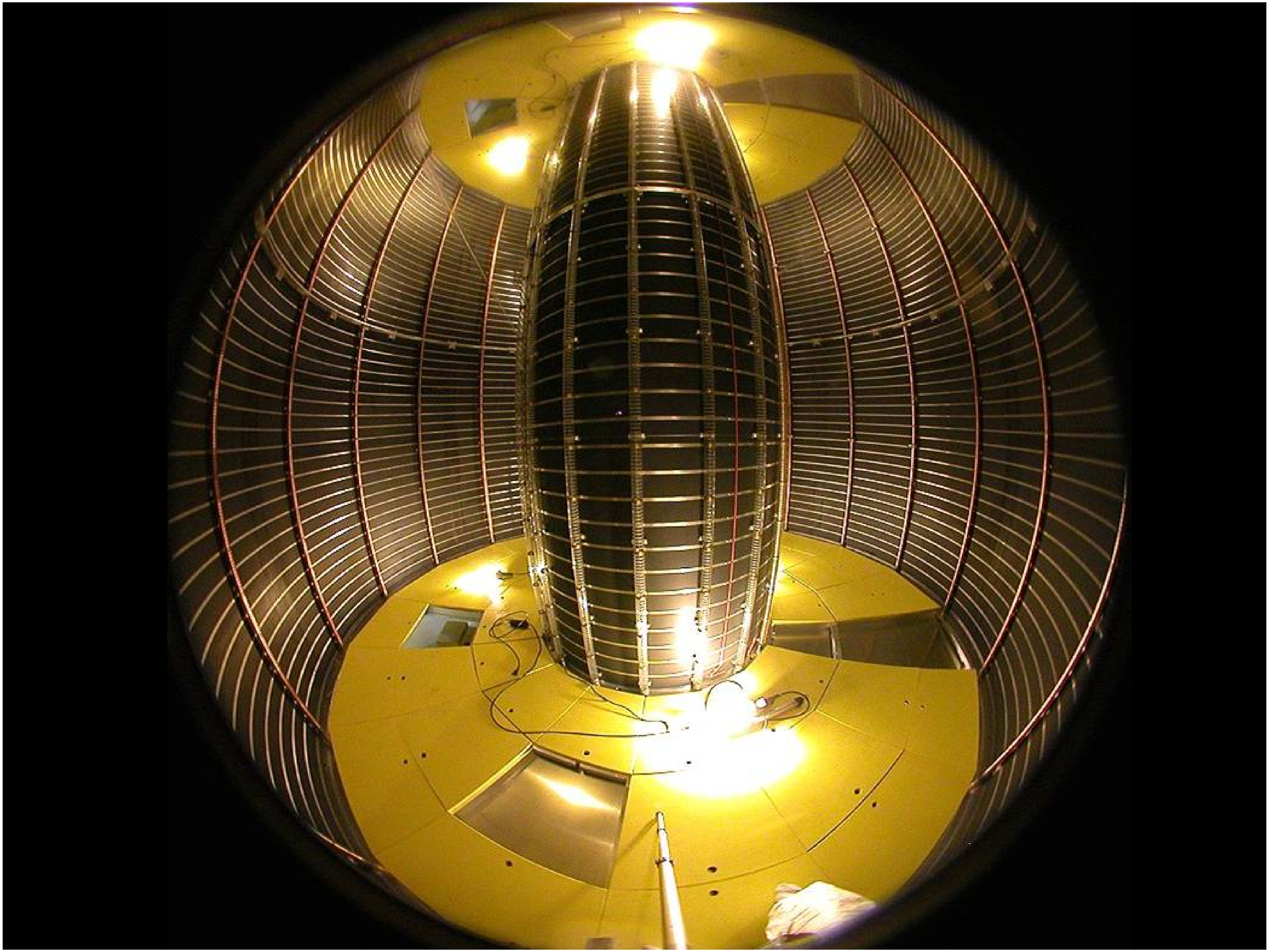
- Starts take data 2007/2008
- Study coloured charged particles in colour charged medium
- Characterize Quark Gluon Plasma
- Apply QCD on system that it has not been tuned for
- Jets higher PT than at RHIC, easier to distinguish from soft
- Many Heavy flavour probes of QGP available

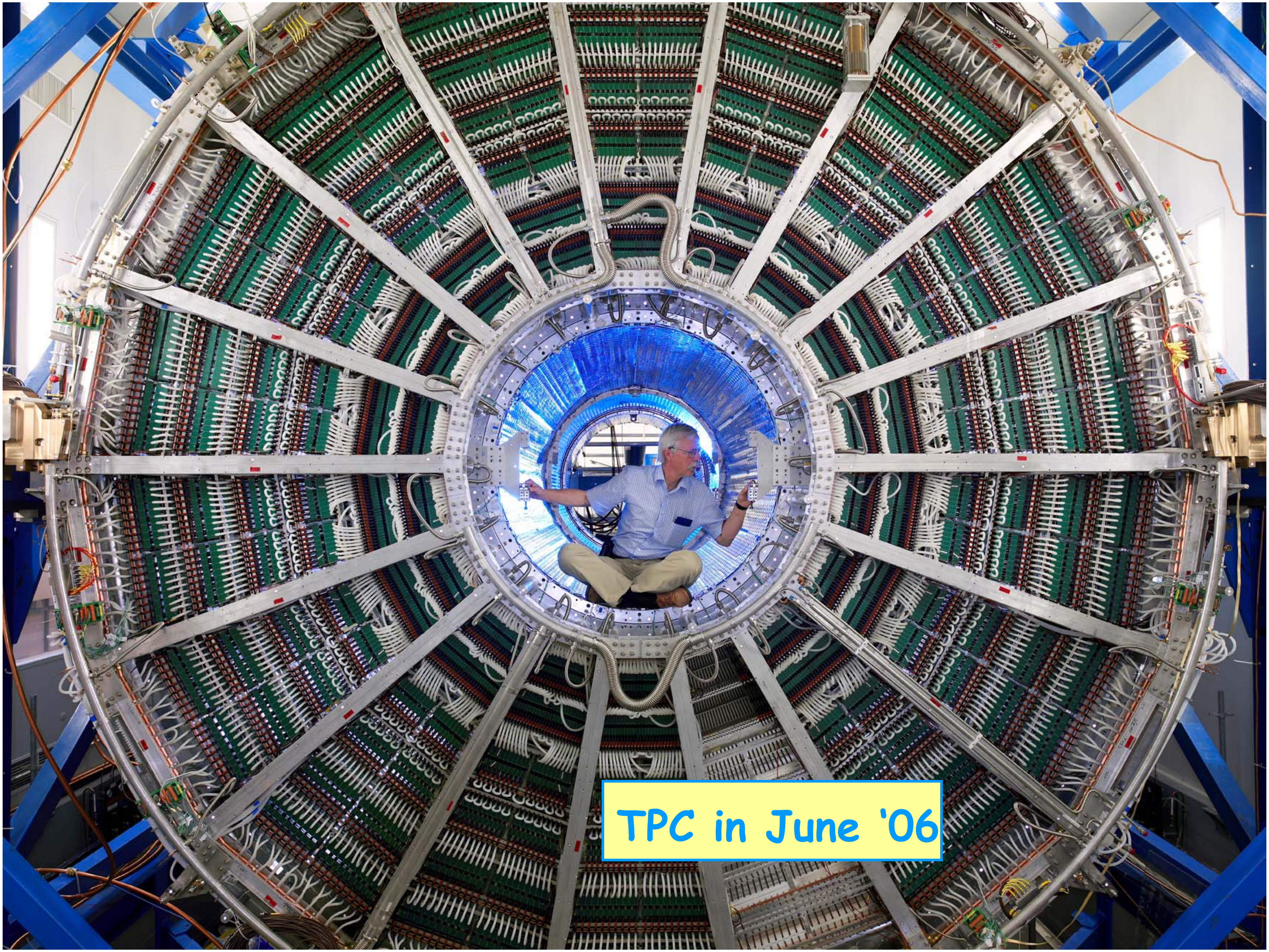
+ gigantic step in energy, surely something unexpected may show up.

ALICE today

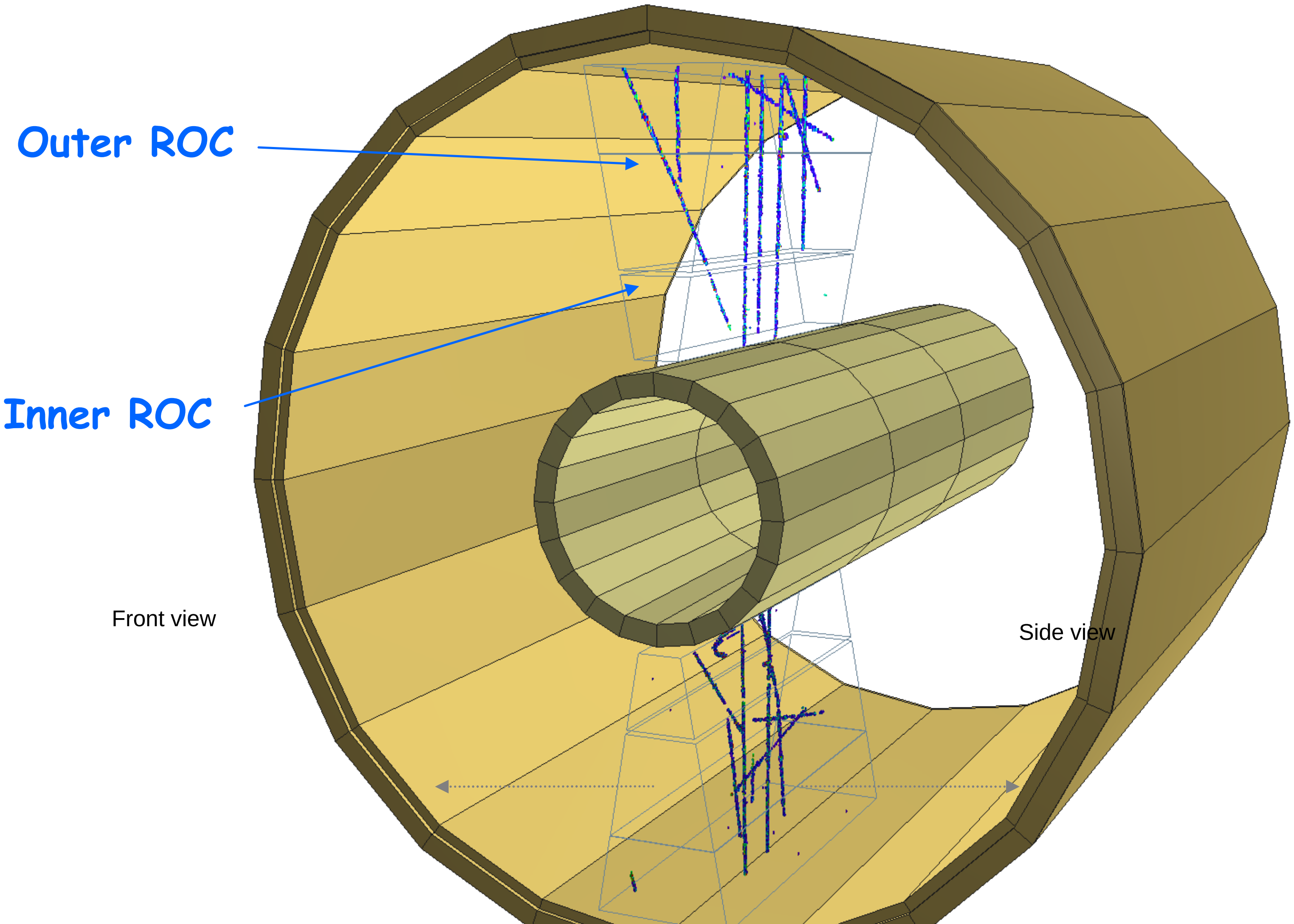







TPC in June '06

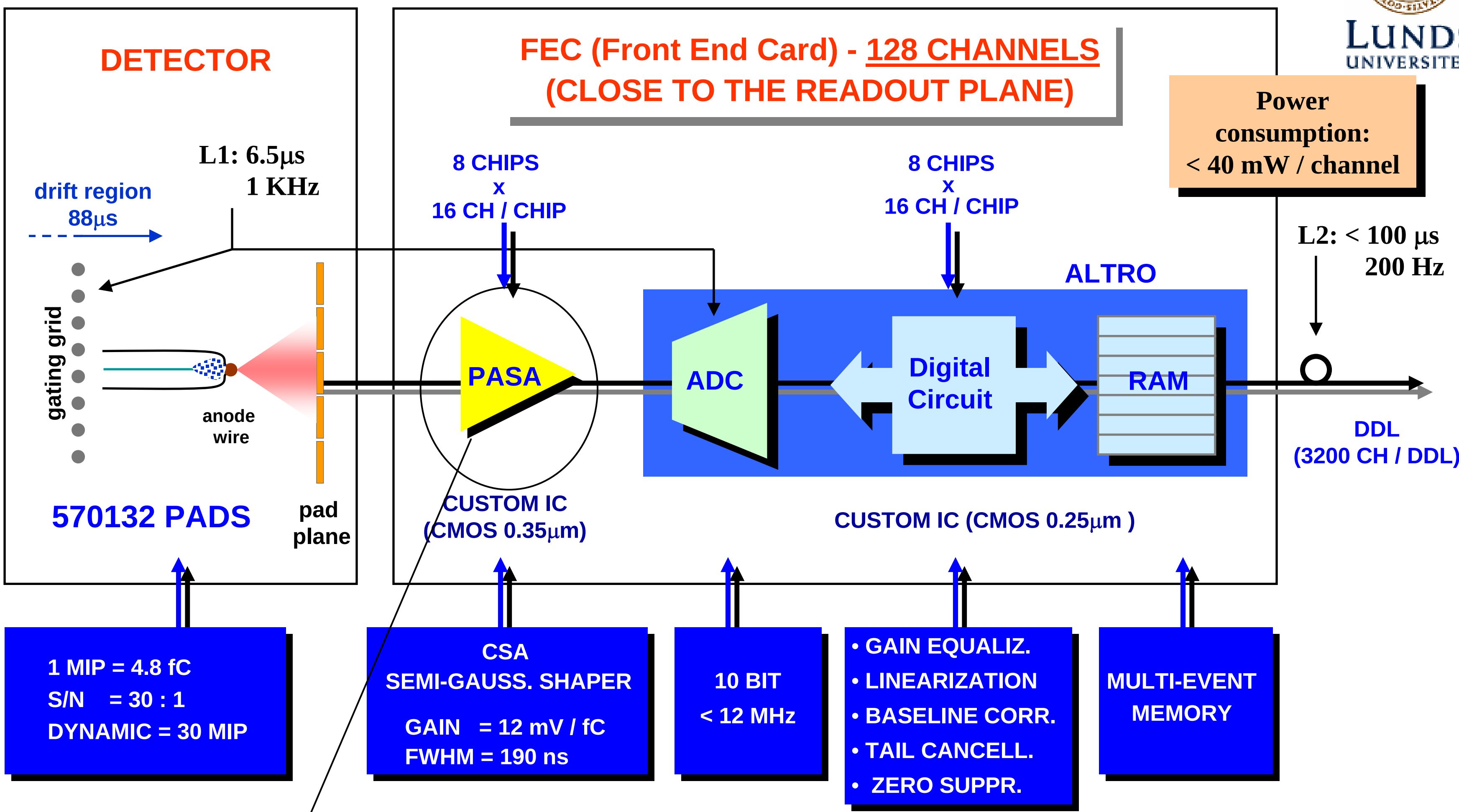
TPC readout electronics from Lund



3-dimensional view of a shower induced by cosmic rays

ALICE front end card in reality, 128 channel digital scope
Lund Hardware contribution to ALICE

ALICE front end card



Need new preamp-shaper chip,
Programmable pol. Gain, shaping time
190nm process

Diploma projects
ex-jobb

Analyze test results from ALICE TPC
-Test and develop algoritms for tracking and Particle ID
-Develop and test monitoring software

First tests of small TPC with GEM readout (ILC type).
-Put small TPC in operation. Hardware in Lund.
-Test with cosmics, sources. Analyse performance
-Possibly test some medical imaging application